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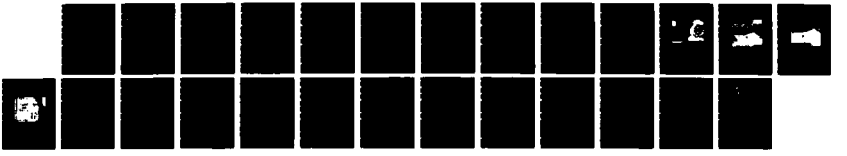

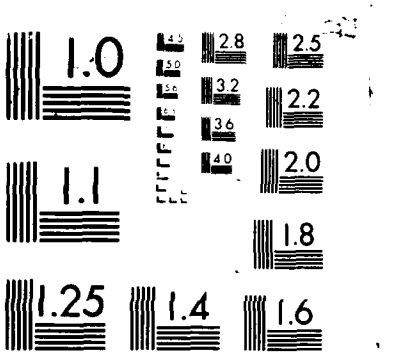

MICROCOPY RESOLUTION TEST CHART

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NATIONAL COMMUNICATIONS SYSTEM

TECHNICAL INFORMATION BULLETIN 86-5

STANDARD GRAY SCALE IMAGES USERS MANUAL

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The CCITT is now in the process of developing standards for the transmission of gray scale, or continuous tone, monochromatic imagery as part of the Group 4 facsimile recommendations. The digital transmission of gray scale imagery is of particular importance to the government for the transmission of photographs, half-tones, maps, etc. Unfortunately, at the present time there is no standard set of gray scale images which can be used by all experimenters in the facsimile field. The purpose of this project is to develop such a set of standard images and provide them in digital form on magnetic tape of facsimile experimenters for use in the development of gray scale techniques to be considered for standardization. The tapes are available from the NCS. The purpose of this manual is to describe the format and content of the image tapes in sufficient detail so that a user can make use of the information on the tapes easily.

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STANDARD GRAY SCALE IMAGES USERS MANUAL

September 1986

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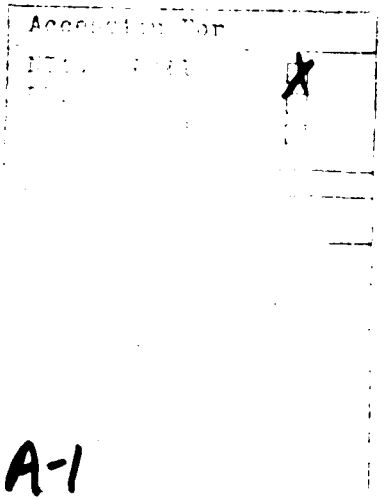
FOREWORD

Among the responsibilities assigned to the Office of the Manager, National Communications System, is the management of the Federal Telecommunication Standards Program. Under this program, the NCS, with the assistance of the Federal Telecommunication Standards Committee identifies, develops, and coordinates proposed Federal Standards which either contribute to the interoperability of functionally similar Federal telecommunication systems or to the achievement of a compatible and efficient interface between computer and telecommunication systems. In developing and coordinating these standards, a considerable amount of effort is expended in initiating and pursuing joint standards development efforts with appropriate technical committees of the Electronic Industries Association, the American National Standards Institute, the International Organization for Standardization, and the International Telegraph and Telephone Consultative Committee of the International Telecommunication Union. This Technical Information Bulletin presents an overview of an effort which is contributing to the development of compatible Federal, national, and international standards in the area of facsimile standards. It has been prepared to inform interested Federal activities of the progress of these efforts. Any comments, inputs or statements of requirements which could assist in the advancement of this work are welcome and should be addressed to:



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STANDARD GRAY SCALE IMAGES

USERS MANUAL

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STANDARD GRAY SCALE IMAGES

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1.0 INTRODUCTION

The CCITT is now in the process of developing standards for the transmission of gray scale , or continuous tone, monochromatic imagery as part of the Group 4 facsimile recommendations. The digital transmission of gray scale imagery is of particular importance to the government for the transmission of photographs, half-tones, maps, etc. Unfortunately, at the present time there is no standard set of gray scale images which can be used by all experimenters in the facsimile field. The purpose of this project is to develop such a set of standard images and provide them in digital form on magnetic tape to facsimile experimenters for use in the development of gray scale techniques to be considered for standardization. The tapes are available from the NCS. 1/

The purpose of this manual is to describe the format and content of the image tapes in sufficient detail so that a user can make use of the information on the tapes easily. A brief outline of the major sections of this manual follows: Section 2 explains the rationale behind the choice of images and associated parameters; Section 3 describes the image scanning process; Section 4 outlines the magnetic tape data formats; and Section 5 contains photographic prints (copies) of the original images.

1/ Copies of the image tapes may be obtained from:

Dennis Bodson, NCS, Attention NCS-TS, Washington D.C. 20305

Phone: (202) 692-2124

2.0 IMAGE AND PARAMETER SELECTION

Four images were selected from fourteen candidates, digitized, and written on magnetic tape at four resolutions. The following paragraphs discuss the factors affecting the selection, and other related parameters such as image size and scanning resolution.

2.1 IMAGE CONTENT

A number of general desirable characteristics to be incorporated in a set of gray level test images might include:

1. A gradual change in gray level values over a broad area (shows possible contouring effects of certain compression algorithms);
2. A range of textures and other small repetitive patterns;
3. Vertical, horizontal, and diagonal edges;
4. Areas of high detail/contrast to challenge compressibility;
5. Both high and low contrast images;
6. Features that can be used to obtain some quantitative measure of resolution;
7. Subject material representative of typical applications.

The four digitized images were chosen with the characteristics listed above in mind. The choices as well as the characteristics were reviewed with members of the TR-29 facsimile committee of the EIA to ensure their concurrence. Figures 2-1

through 2-4 are halftone representations of these images showing the exact size at 200 pixels per inch of each of the digitized images on tape. Copies of the original images used to prepare the tape are in an envelope attached to the back cover of this manual. Image Number 1 is part of the IEEE Std 167A-1980 Facsimile Test Chart. This image provides a means to measure the effects of a given compression algorithm on resolution by examining the resolution wedge or line pair chart. In addition, the photograph of the woman serves as a typical example of an identification photo.

Image Number 2 and Image Number 3 are examples of pictures that a realtor might use to enhance a property description. Number 2 includes a large area of gradually changing gray, a number of areas of different textures, and various horizontal, vertical, and diagonal lines. Number 3 is similar, but includes areas of extremely high detail.

Image Number 4, an aerial photograph, is a low contrast image of high detail, although not very high resolution.

2.2 IMAGE SIZE AND RESOLUTION

The image size, approximately four inches by five inches, that was selected for this project is the result of a compromise. On one hand, a small image is easier to process, requiring less computer time and mass storage. Also, a soft copy high resolution display is typically limited to 1000 to 2000 lines resolution. Standard TV is only 525 lines. On the other hand, the image should be large enough to evaluate visually, or a size on the

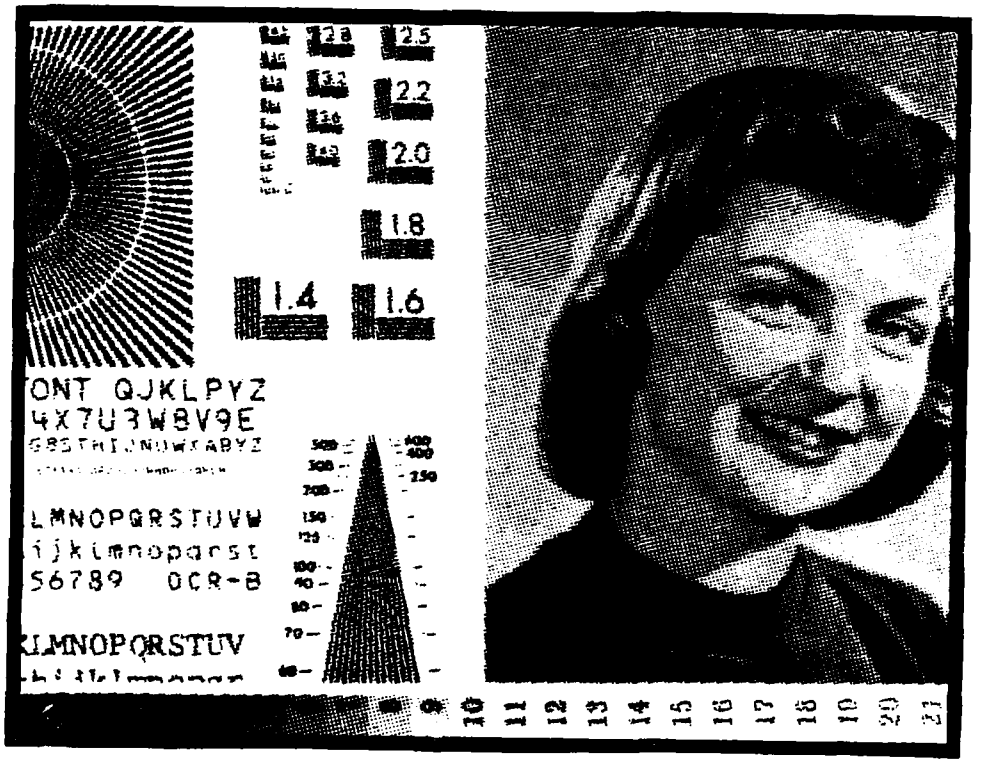

FIGURE 2-1. IEEE

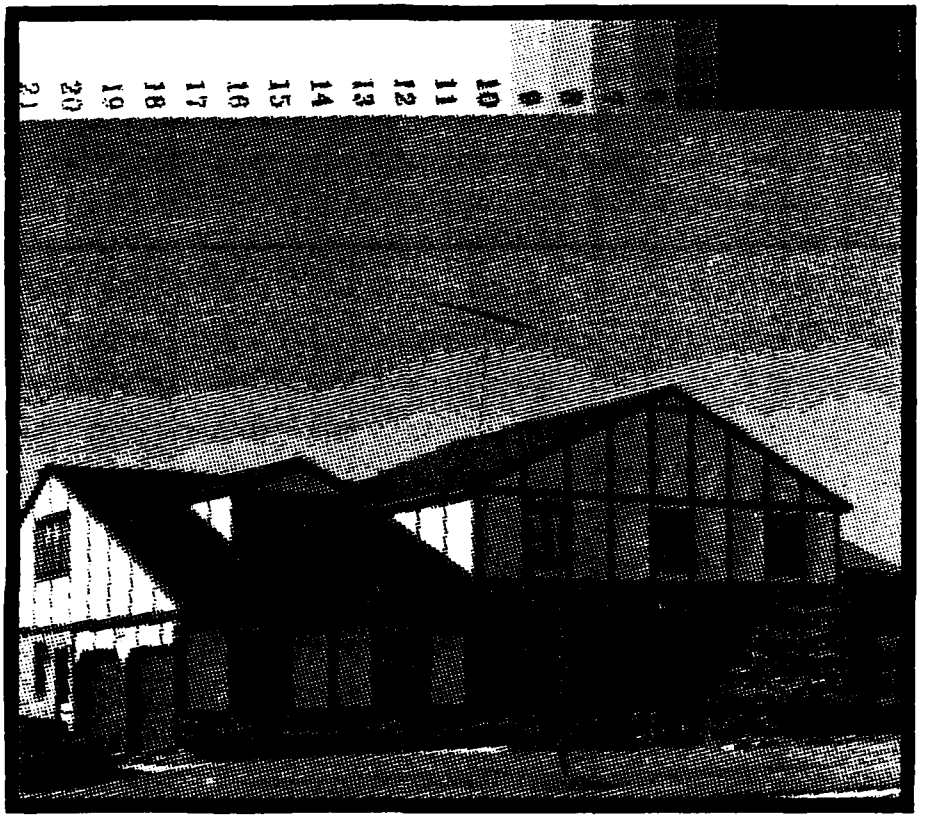

FIGURE 2-2. HOUSE AND SKY

FIGURE 2-3. HOUSE WITH TREES

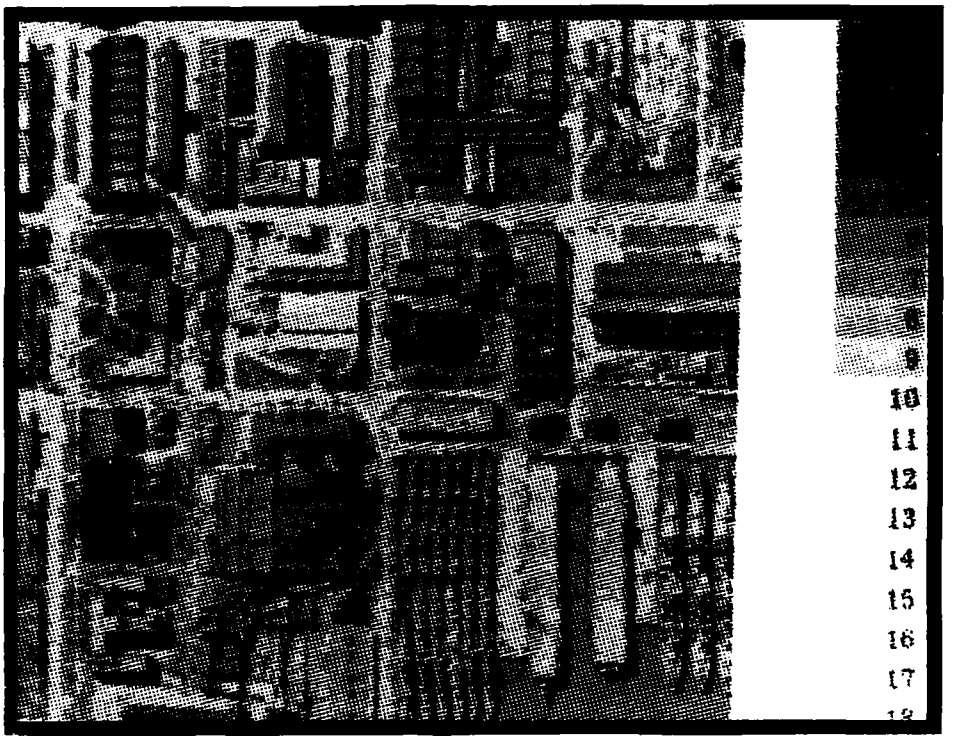

FIGURE 2-4. AERIAL PHOTOGRAPH

order of that in an actual application.

The resolution of the digital images is determined by the CCITT recommendations for Group 4 apparatus. These are 200, 240, 300, and 400 pixels per inch in both horizontal and vertical directions. Each pixel was encoded to eight bits, since this is both a convenient number for most equipments, and it provides more gray shades than the human eye can discern in most instances.

3.0 IMAGE SCANNING

The four images selected for the standard image set were scanned, digitized, and written on magnetic tape at four resolutions. The scanning process was performed by the Massachusetts Institute of Technology Cognitive Information Processing Group, using a modified ECRM Autokon scanner. This scanner is somewhat restricted in that its scanning aperture size cannot be adjusted to an arbitrary value. To obtain the standard Group 4 resolutions, each image was scanned once at 1200 pixels per inch, and then filtered and subsampled to produce an image with the appropriate aperture size for each of the final resolutions (200, 240, 300, and 400 pixels per inch). The images were scanned from left to right and top to bottom at eight bits per pixel; 8-bit precision yields a gray scale range of $2^8 = 256$ levels, where zero represents full black and 255 represents full white.

The distribution of the gray levels throughout each image was quantitatively measured by constructing histograms in which the number of occurrences of each gray level value (0-255) was plotted vs. the gray level value itself. In each gray level histogram, the abscissa is gray level value and the ordinate is frequency of occurrence of that gray level. Figures 3-1 through 3-4 present the histograms for the four standard images at 200 pixels per inch; histograms for the images at the higher resolutions are proportional. The gray scale step chart that was included in each image during scanning (for calibration purposes) was omitted from the histograms so that it would not bias the distribution curves

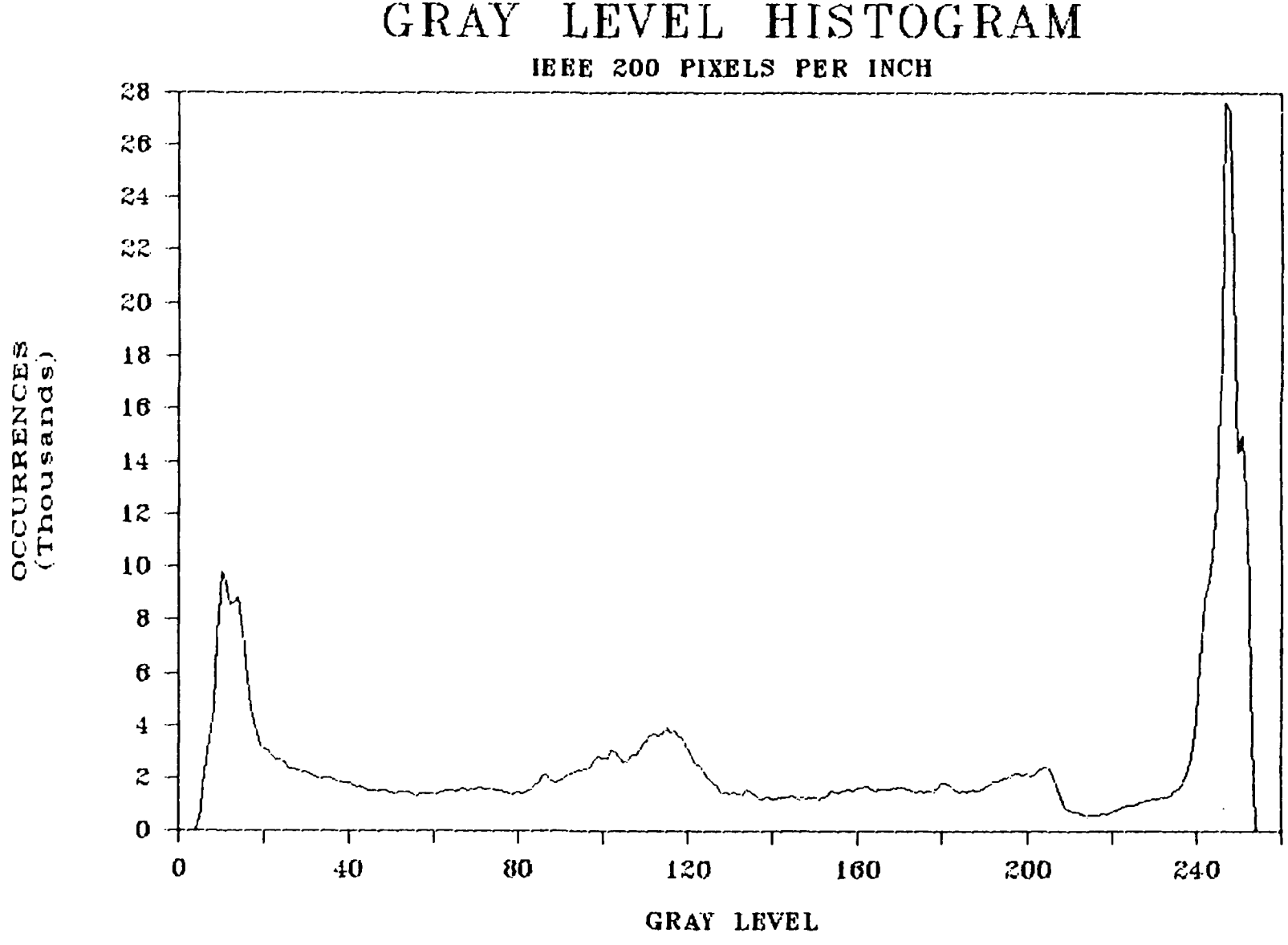

FIGURE 3-1. IEEE HISTOGRAM

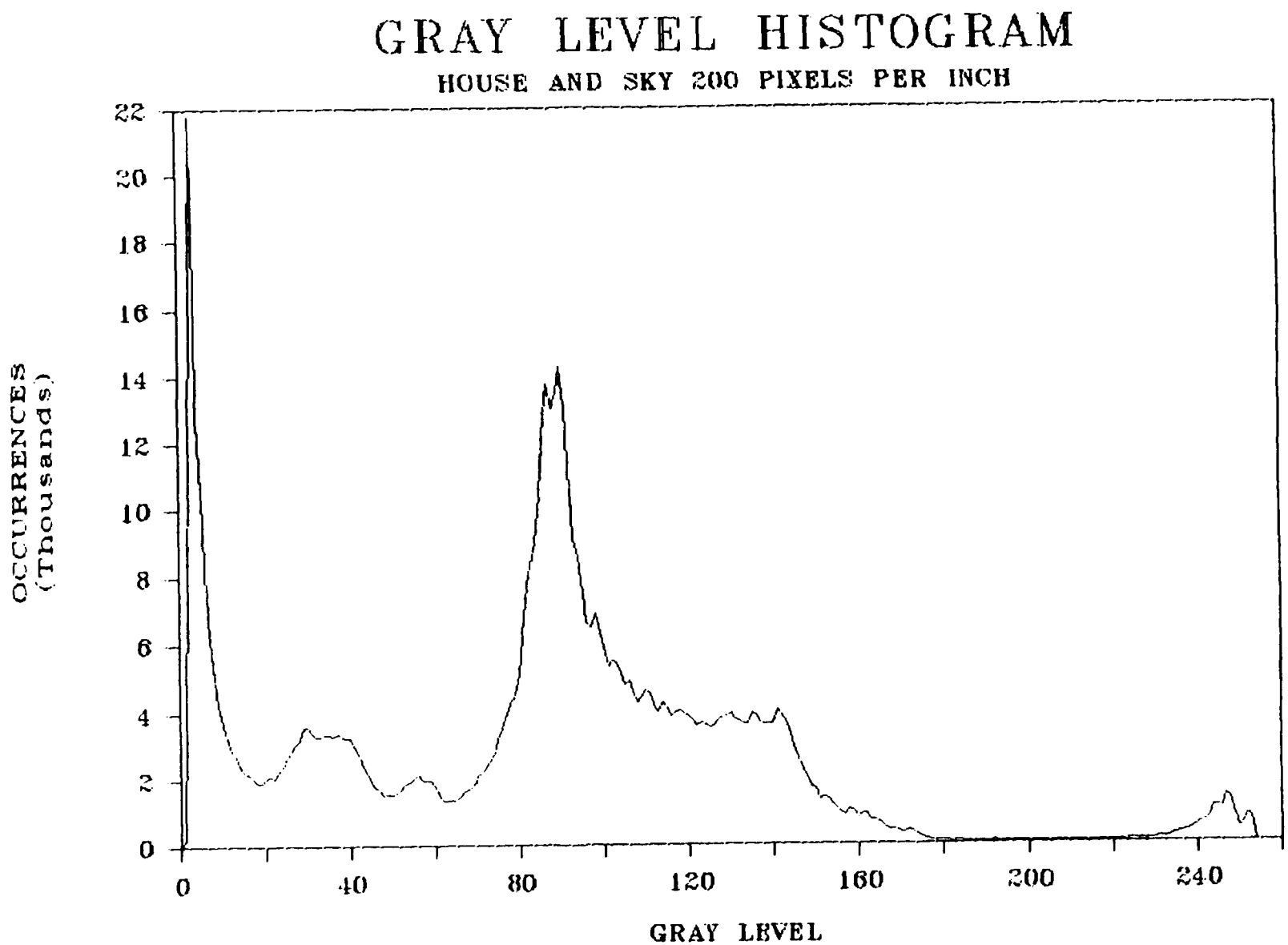

FIGURE 3-2. HOUSE AND SKY HISTOGRAM

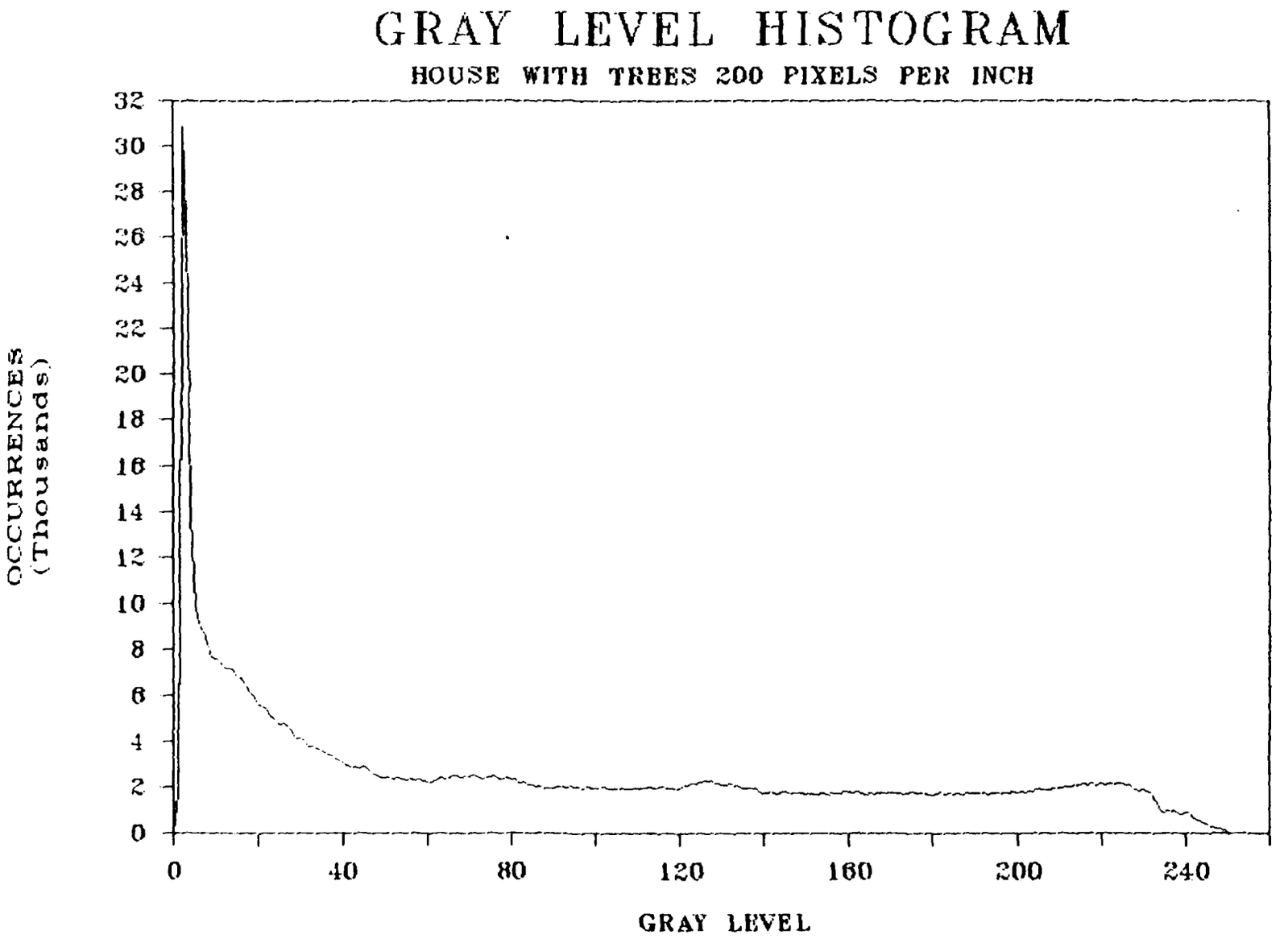

FIGURE 3-3. HOUSE WITH TREES HISTOGRAM

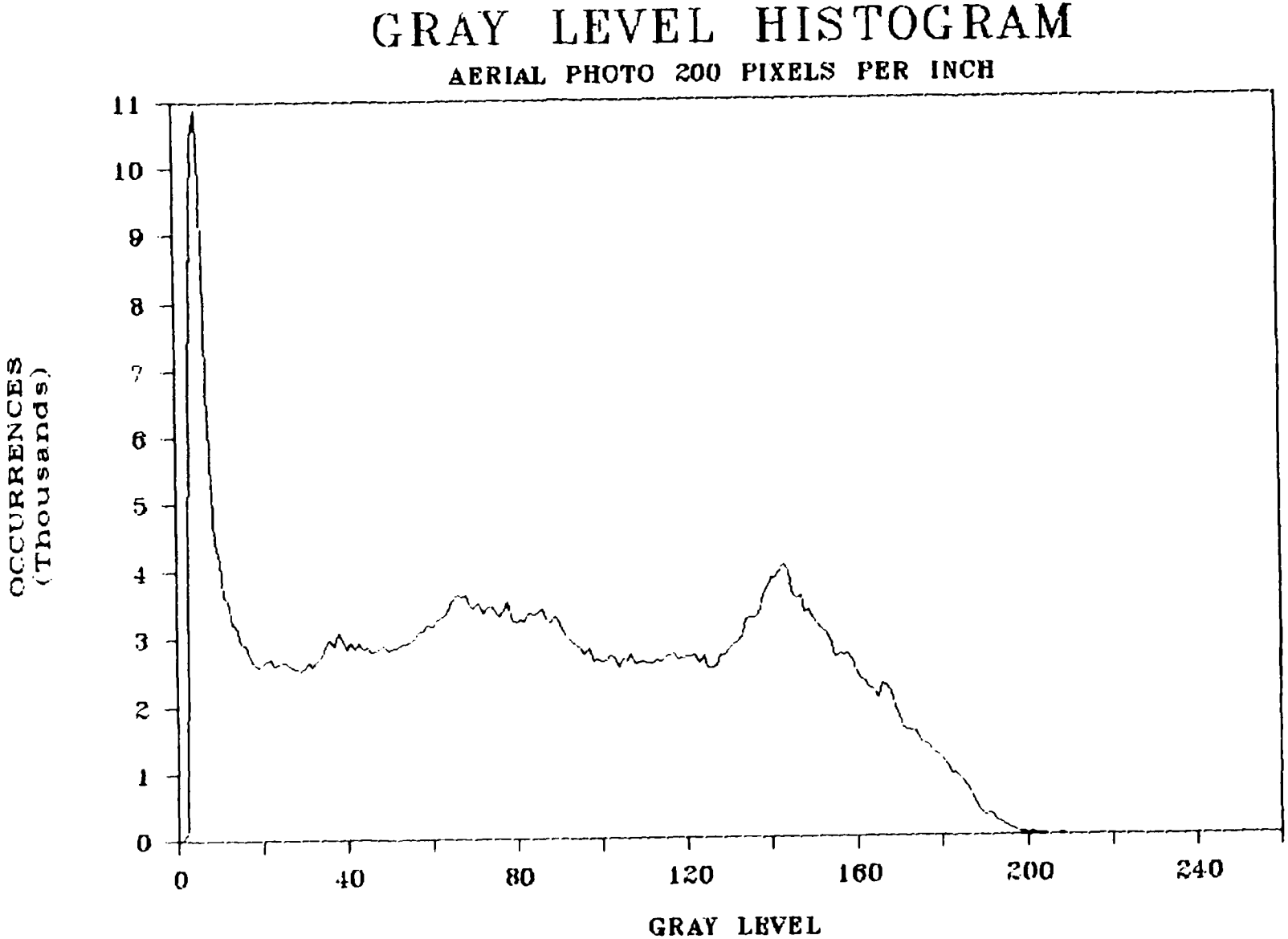

FIGURE 3-4. AERIAL PHOTO HISTOGRAM

by adding abnormally high peaks at the gray level values represented in the step chart.

A 512 pixels/line x 512 lines "window" was extracted from each of the 16 test images; the purpose of these extracted windows is to provide experimenters with portions of each image that can be displayed on a soft copy medium (e.g. high resolution monitor, standard TV). The window size was chosen because 512 x 512 (x 8 bits/pixel) is both a convenient computer memory storage size and is close to the standard television resolution (525 x 480). The windowed images were selected so that they contained information that was representative of the entire image. The windowing was performed such that, for each of the four test images, the extracted window at each resolution was a successively smaller portion of the window associated with the previous resolution, as illustrated in Figure 3-5.

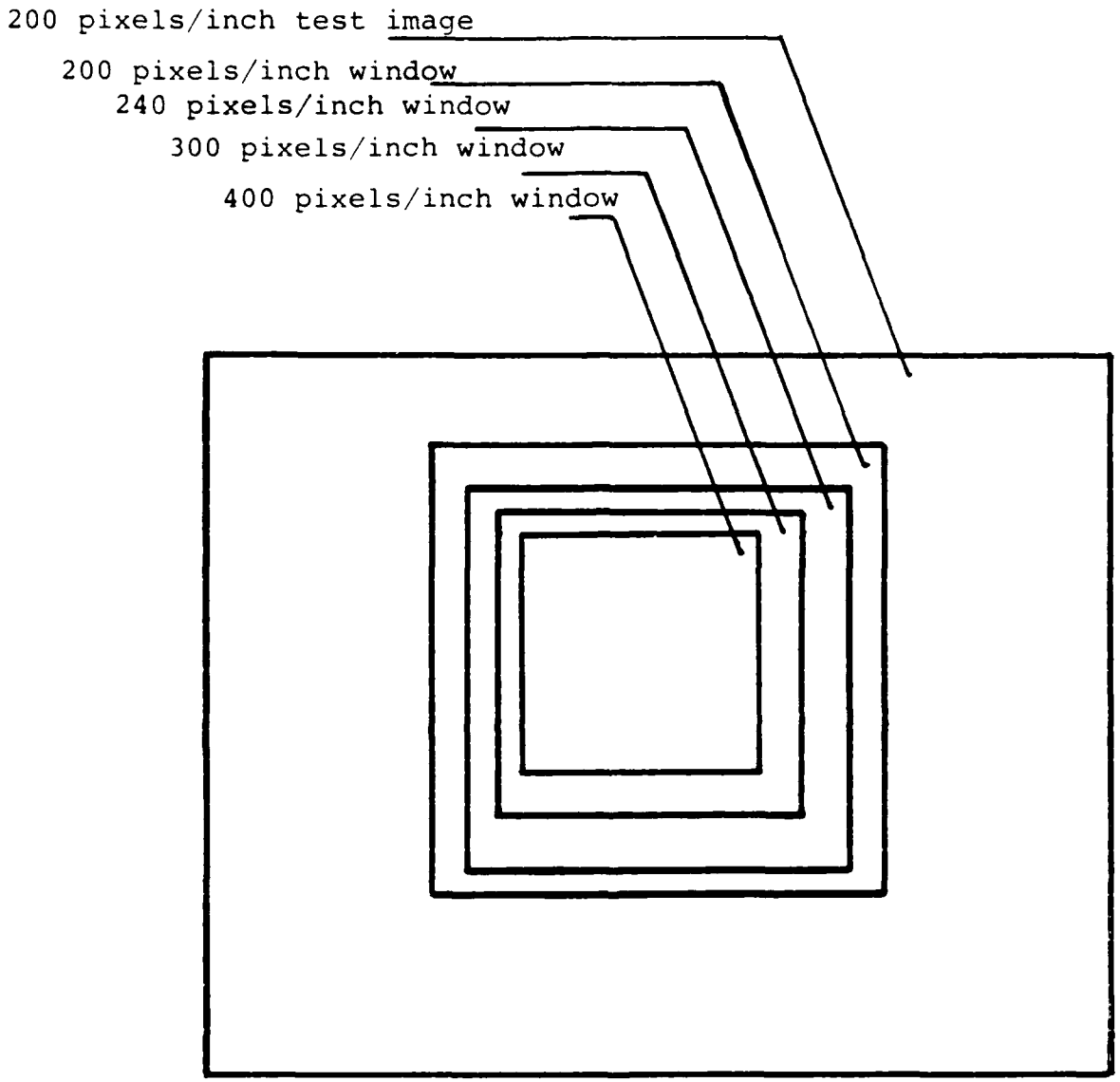

FIGURE 3-5. WINDOWING PROCEDURE

4.0 DATA FORMAT ON TAPE

Thirty-two images are recorded on two reels of magnetic tape, each 2400 feet in length with a recording density of 1600 bpi. The image files are arranged so that the eight files associated with each test image are grouped together. For each test image, the full image scan at each resolution is presented, followed by the soft copy windowed images extracted from them; the order of the image files corresponds directly to that in Table 4-1. Each of the thirty-two images is recorded in a separate file on the tape. Each file is followed by a tape mark (EOF). The tapes are IBM format, unlabeled, with fixed length records, one image scan line per record, and one byte per pixel. Refer to Table 4-1 for the number of pixels per record and records per file for each image. Also included are the approximate lengths of magnetic tape required at recording densities of 800 bits per inch and 1600 bits per inch.

TABLE 4-1 MAGNETIC TAPE PARAMETERS

Image Name	File Number	Resolution, pixels/inch	Pixels/ Record	Records/ Image	Bytes/ Image	Mag Tape @800 BPI, feet	Mag Tape @1600 BFI, feet
TAPE NO. 1							
IEEE	1	200	980	760	744800	116	77
	2	240	1176	912	1072512	157	101
	3	300	1470	1140	1675800	232	144
	4	400	1960	1520	2979200	386	231
	5	200	512	512	262144	53	39
	6	240	512	512	262144	53	39
	7	300	512	512	262144	53	39
	8	400	512	512	262144	53	39
						1103	710
HOUSE AND SKY	9	200	940	830	780200	123	82
	10	240	1128	996	1123488	167	108
	11	300	1410	1245	1755450	245	154
	12	400	1880	1660	3120800	408	246
	13	200	512	512	262144	53	39
	14	240	512	512	262144	53	39
	15	300	512	512	262144	53	39
	16	400	512	512	262144	53	39
						1155	746
TAPE NO. 1 TOTAL						2258	1456
TAPE NO. 2							
HOUSE WITH TREES	1	200	940	820	770800	121	81
	2	240	1128	984	1109952	165	107
	3	300	1410	1230	1734300	242	152
	4	400	1880	1640	3083200	403	243
	5	200	512	512	262144	53	39
	6	240	512	512	262144	53	39
	7	300	512	512	262144	53	39
	8	400	512	512	262144	53	39
						1143	739
AERIAL PHOTO	9	200	960	750	720000	112	75
	10	240	1152	900	1036800	153	99
	11	300	1440	1125	1620000	225	141
	12	400	1920	1500	2880000	375	225
	13	200	512	512	262144	53	39
	14	240	512	512	262144	53	39
	15	300	512	512	262144	53	39
	16	400	512	512	262144	53	39
						1078	696
TAPE NO. 2 TOTAL						2221	1435
OVERALL TOTAL						4479	2891

5.0 SAMPLE PRINTED IMAGES

A copy of each of the four original images is included with this manual in a pocket attached to the back cover. Please be advised that the gray level values of the copies may not match exactly those of the originals.

END

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